Willard Bay Project Proposal

Applicant: Toby D. Hooker

Project Title: Use of Remote Sensing to Detect and Quantify Algal Mat Cover in Great Salt Lake Wetlands

Agency: Utah Division of Water Quality (DWQ)

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Applicant Type: State Government Agency

1. Estimated Project Costs:

Budget Category	Project: Algal Mat monitoring	Explanation
Personnel & Fringe	$ 67,078	Salary for DWQ project manager, including 44% fringe benefits.
Supplies	$ 4,000	Consumable materials, including fact sheets and data sheets, and field monitoring equipment (water filters, hand pump, etc.) and PPE (estimated).
Miscellaneous	$ 3,354	Support for staff services, calculated as 5% of personnel and fringe costs
Contractual	$ 101,650	Anticipated costs for obtaining remote sensing imagery and completion of GIS analysis tasks by USU RS-GIS Laboratory over two year project period; and analysis of algal mat samples.
Administration {Indirect Costs}	$ 7,519	Calculated as 11.21% of personnel and fringe costs
Total requested funds	$ 183,601	

Other Sources of project funding:

	Funding Source	Amount
1	DWQ Aquatic Monitoring Resource funds (technician salaries)	$ 26,467
2	Utah appropriation for water analyses (UPHL)	$ 7,501
	TOTAL	$ 33,968

Total Project Cost (all funding sources): $ 217,569

2. Project Description

This project [**Use of Remote Sensing of Algal Mats and Pond Vegetation**] is intended to investigate and develop the use of remote sensing for assessing Great Salt Lake (GSL) wetlands. The multi-disciplinary project team of DWQ wetland and Utah State University remote sensing scientists will evaluate the effectiveness and costs of using multi-spectral imagery to identify the frequency and areal extent of deleterious large algal mats and beneficial submerged aquatic vegetation (SAV) in the wetlands on the east side of GSL (See **Map 1** [attached]). This project builds on existing work by DWQ's *Wetlands Program* developing tools to assess the health of wetlands associated with GSL.

DWQ is currently working on several complimentary projects funded by the USEPA Wetlands Program Development Grants to identify appropriate biological, chemical and physical responses that describe how GSL wetlands respond to stress. Stressors can include physical stressors and chemical stressors. Physical stressors include factors such as water quantity and habitat quality. Chemical stressors include spills, such as the Willard Bay diesel spill or a permitted discharge such as the Willard-Perry wastewater treatment plant. The specific focus of the research contained in this proposal is focused on impounded wetlands. These wetlands are primarily managed by state and federal agencies, and private wetland management groups, for waterfowl production and include wetlands adjacent to Willard Bay. These wetlands contribute to GSL's function as habitat of hemispheric importance for migratory birds. These wetlands are also enjoyed by thousands of Utahn's recreating through boating, bird watching, or waterfowl hunting.

Through DWQ and others' work, biological response variables have been identified for wetland ponds that appear to be important descriptors of ecological health and are responsive to ecosystem stress, including: (1) cover of submerged aquatic vegetation (SAV); (2) relative abundance of plant-associated macroinvertebrate taxa; and (3) the lack of extensive mats of algae on pond surfaces. In addition, results from the site-specific Willard Spur study highlight seasonal and hydrologic linkages between SAV cover and macroinvertebrates, and illustrate the importance of temporal variations within GSL wetlands. Key factors that control the development of SAV or algal mats are currently unidentified, in part because of difficulties in anticipating when and where SAV or algal mats are undergoing change. In fact, accurate characterization of the extent and frequency of early senescence of SAV and algal mats is currently unavailable, including how these vary year-to-year and season-to-season. The use of remote sensing to determine the timing of key events in SAV cover or the development of algal mats can then be used to provide context for the wetland health metrics.

One important aspect of a successful and scientifically valid wetland monitoring program rests on the idea that measurements are collected at the appropriate spatial and temporal scales. Given that GSL wetland ponds range in size from less than 4 to over 5000 acres, recent advances in remote sensing and GIS analysis may be a more cost-effective approach to routine monitoring of some water quality parameters such as algal mat cover (Ritchie et a., 2003; Torbick et al., 2013) than intensive site surveys. Algal mats are a significant concern for Utah duck hunters (Duffield et al., 2011) and are commonly indicative of nutrient-related stress to aquatic systems. In contrast, SAV cover is an important attribute of healthy ponded ecosystems (DWQ, 2009; DWQ, 2014). **The project described in this proposal will support DWQ's ability to monitor and track the frequency of occurrence, extent, and severity of potentially harmful algal blooms and the cover of desirable SAV within wetlands adjacent to GSL**.

This project will be conducted through collaboration with Utah State University's *Remote Sensing and GIS Laboratory*[*]. If successful, this approach will provide a cost-effective method for monitoring fundamental aspects of biological responses of aquatic systems across the GSL landscape, and may have ancillary benefits for monitoring other waters in Utah. This project supports the refinement and application of GSL-wetland assessment tools, and will provide a basis for public engagement with wetland-focused stakeholders.

[*] USU's RS/GIS Laboratory. See: www.gis.usu.edu.

3. Project Milestones

TASKS	2014		2015				2016			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective 1: Remote Sensing & GIS of Algal mats and SAV										
Task 1: Literature Review	Lit. Review									
Task 2: Review of Available Imagery Data		Data Review								
Task 3: Develop Mapping Methodologies				Acquire Data & Field Verify				Acquire Data & Field Verify		
					Data Processing and Analysis			Data Processing and Analysis		
Task 4: Final Report									Final Report	

Note: Task schedule is described for planning and methodological review in 2014, with data collection and analysis in 2015 & 2016, and final report in late 2016 or Q1 2017. If preferred, data collection can be initiated on an earlier timeframe and described in the second phase project plan (per the RFP).

Project Tasks:

1) Literature review to assess methods and data previously used to identify, map, and monitor algal blooms, surface mats, and SAV within shallow waters. Report will be submitted by Dec. 31, 2014 and made available for public review.
2) Review of available air- and space-borne remote sensing platforms to ensure use of the most appropriate data for mapping and monitoring. Selection will be based on the proper spatial and spectral resolutions to meet the project need, as well as data availability (spatial and temporal) and cost.
3) Develop and test algal mat and SAV identification, characterization, and mapping methodologies best suited for GSL wetlands. Project goal is to test data and methods across a seasonal sequence of algal mat development over two years. Map and model development will be completed using image analysis tools such as Erdas Imagine 2014, ESRI ArcGIS 10.2, and the R statistical package. Field work will be performed by DWQ personnel and USU graduate student.
4) Development of a detailed Final Report on the methods, results, and interpretation of project goals. This report will also detail the elements required to develop an automated or semi-automated approach to identifying, mapping, and monitoring algal mats and SAV on the study area.

4. Project Location

The project area is shown in **Map 1** (see attached). This area includes the eastern portion of Great Salt Lake and wetlands associated with Bear River and Farmington Bays. The wetland ponds account for over 95,000 acres (38,700 ha), while the open water areas of Bear River Bay (including Willard spur and Willard Bay Reservoir) and Farmington Bay represent over 129,000 acres (52,250 ha) and 97,500 acres (39,400 ha), respectively. These wetland areas are highly valued as habitat supporting waterfowl and shorebird production on statewide, regional and national scales.

5. Project Impact

This project will enhance and protect broad areas of open water and ponded wetlands associated with Great Salt Lake by improving DWQ's ability to monitor the frequency and extent of nuisance algal blooms

and beneficial aquatic vegetation at a spatial scale appropriate to the Great Salt Lake basin. If successful, this project will provide a methodology for the semi-automated analysis of seasonal patterns of algal mat and SAV cover for open water areas of wetland ponds as well as mesosaline areas of Great Salt Lake. Timely results will help DWQ and other aquatic resource managers adapt to potential threats to water quality by providing valid and verifiable information on the spatial extent and frequency of for example, nuisance algal blooms.

Successful implementation of this project over time can also enhance and protect wildlife by identifying spatial patterns of excellent vs. degraded habitat, and by supporting more focused ecological monitoring of degraded vs. reference conditions following DWQ's tiered monitoring approach. For example, results from a 50-site probabilistic survey of wetland ponds revealed that the Lower Weber River subwatershed had low SAV but high algal mat cover, while the Jordan River subwatershed was dominated by ponds with extensive SAV *and* algal mats. It is not clear how extensive these disparate patterns are within and among subwatersheds; as such, remedies or ameliorative actions remain difficult to implement. It is our hope that being able to quantify the size of potential problems, including the frequency, extent and magnitude of algal mats among duck ponds, will increase the Utah's ability to identify and implement solutions.

This project could also offer opportunities for wide-scale monitoring of other water quality parameters, as well as emergency response, by building the technical and analytical skill set to infer a broad range of water- and land-based constituents based on changes in spectral signatures of the ground / water surface.

6. Project Connectivity

This project directly supports Utah's Wetland Program Plan (WPP), by developing tools to assess important biological indicators of wetland health. This project also directly builds on prior work building wetland assessment tools, including both impounded and fringe wetlands associated with Great Salt Lake. In addition, the project builds on broad-scale efforts to develop site-specific water quality standards for wetlands (e.g. the Willard Spur WQS project), by establishing analytical techniques to monitor both positive (cover of SAV) and negative (cover of nuisance algal mats) indicators of wetland health over the long term. Finally, this project will help wetland water quality managers better understand how both healthy and degraded wetlands are distributed within the Great Salt Lake basin, and how the health of wetlands can impact or ameliorate the health of downstream aquatic resources.

7. Project Social Benefits

Social benefits to residents of Utah from successful completion and implementation of this project include both outputs (or work products) and environmental outcomes.

Outputs that are anticipated to result from the work in this proposal :

- Development of monitoring protocols for landscape-scale assessment of wetland algal mats and SAV cover
- Refinement of stressor-response models and assessment criteria used to report on the ambient condition of GSL wetlands

Environmental Outcomes that are anticipated to result from the work in this proposal :

- Develop a better understanding of the natural range of variation of wetland-specific water quality measurements
- Improved wetland assessment efforts
- Improved wetland protection efforts by developing appropriate biological endpoints for wetland narrative standards
- Better integration of board-scale surveys with intensive, site-specific investigations

8. Project Planning

Objective: Develop methods for cost-effective monitoring of algal mats and other aquatic vegetation at broad spatial scales. This project will detect and quantify the incidence and extent of algal mats and SAV cover of open water wetland areas (ponds and meso-saline areas of Great Salt Lake) using remote sensing-derived data and GIS analysis. This project will be performed through collaboration with the Utah State University Remote Sensing and GIS Laboratory (RS/GIS Lab), and includes four main steps:

1) Literature review of the use of remotely sensed data for identifying, mapping, and monitoring algal mats and SAV. A graduate student will perform the literature search and, in collaboration with RS/GIS Lab and DWQ personnel, will collate and annotate peer-reviewed articles describing methods, successes and failures of efforts to map algal blooms and SAV.
2) Review of RS platforms, data attributes (spatial, spectral, and temporal resolution), and associated costs. These first two steps will be used to identify the most appropriate data type(s) for analysis. This task will also be performed by a graduate student. An array of available datasets for the GSL basin will be compiled, including freely available Landsat data as well as other privately owned platforms. A balance between temporal, spatial and spectral resolution, in addition to data cost, will be evaluated in light of the Literature Review of methods described above. Multiple spatial and spectral datasets will be considered for analysis, at least during the first sampling year.
3) Development and testing of an algal mat and SAV mapping methodology for GSL using the previously defined RS data. The appropriate remotely sensed data will be acquired from vendors, including possible purchase of commercial data to compare with the greater spectral but lower spatial, and freely available, Landsat data. Preliminary planning involves data collection from three 'envelopes' across GSL wetlands, on the order of 10 km x 10 km in size to focus initial efforts. Imagery data and field measurements will be collected multiple times over the growing season; initial planning is for monthly data collections from May through September. Field measures will involve, for each 'envelope', transect based estimates of SAV and algal mat cover for wetland ponds exhibiting a range of conditions. Additional measurements include water samples to be analyzed for chlorophyll-a (from water column and algal mats), total suspended and volatile solids (TSS and TVS; to characterize the inorganic and organic constituents within the water column), and total N and P (to characterize the nutrient status of wetland ponds across a range of algal mat and SAV cover conditions and contribute to wetland condition database). Field measures will be used to support supervised classification of a range of algal mat and SAV covers across imagery platforms and sample dates. The project study area lies along the eastern edge of Great Salt Lake, adjacent to the rapidly urbanizing Wasatch Front. Map and model development will be completed and tested using image analysis tools including Erdas Imagin 2014, ESRI ArcGIS 10.2, and the R statistical package.
4) Detailed Final Report and summary of steps (workflow) required to develop semi-automated tools and methods to map algal mats and SAV, key indicators of wetland water quality monitoring. Funds are requested for two years of growing-season data acquisition and analysis.

9. Project Management Experience of Applicant

The Principal Investigator (PI) for this project is Toby Hooker, Wetland Scientist at DWQ. Toby's background is in natural resource management (BSNR, U. Michigan 1994), ecosystem ecology (MS, U. Rhode Island 2000), and biogeochemistry (PhD, Utah State Univ. 2009), with field, lab, and academic experience in a wide range of temperate ecosystems, and spent 7 years managing a fee-for-service stable isotope research laboratory. Toby has successfully managed grant-funded wetland projects for 4 years; he

is currently managing 3 EPA-funded wetland program projects. The PI will be responsible for overall project management, including review and completion of sampling plans and interim project products, as well as ensuring the timely completion of the project Final Report.

10. Project Maintenance

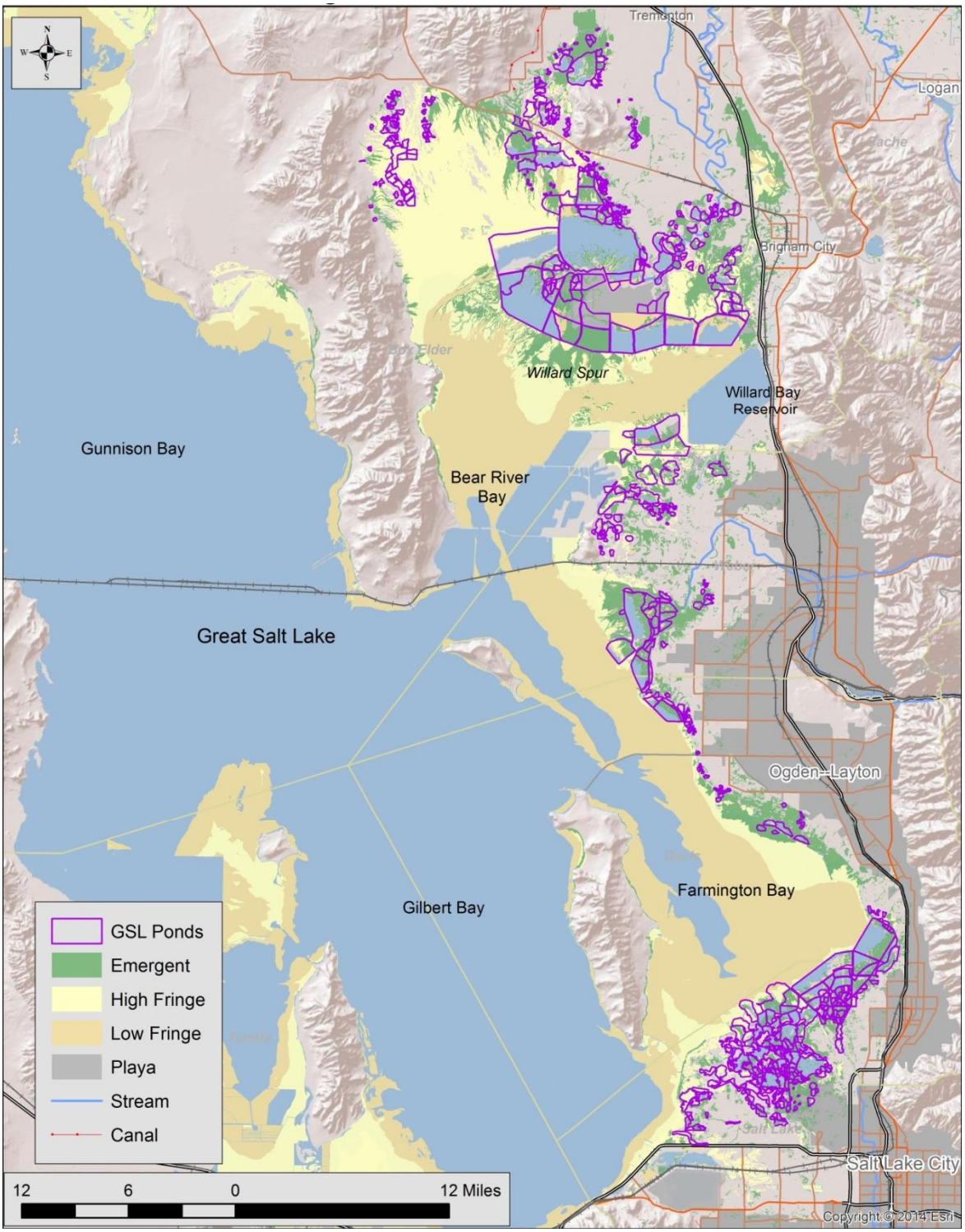
Since this project does not involve on the ground mitigation or restoration activities, no project maintenance is required.

11. Project Partners

The main partners supporting this project are Dr. Douglas Ramsey (Director) and Christopher McGinty (Associate Director) of the Remote Sensing / GIS Laboratory at Utah State University. Richard Emerson, GIS Analyst and Geologist at Utah Geological Survey has agreed to collaborate and provide comments on the methodological approach described in this project. Meetings among the PI and project partners will occur at least monthly to discuss progress updates, trouble shooting, and other issues as they arise.

12. Supplemental Information

Map 1. Dominant wetland types for Great Salt Lake project area.



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